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SHORT COMMUNICATION

High demand for firewood leads to overuse of walnut-fruit forests in Kyrgyzstan

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Abstract: After Kyrgyzstan gained independence in 1991, the importance of the primary sector for food- and energy-supply increased significantly. This has led to a discussion about the sustainability of current firewood use. We investigated firewood collection and use practices in three selected villages and analysed differences between the annual increment of woody biomass and firewood consumption for heating during winter months. The calculated individual firewood consumption is on average 3.90 kg/capita/heating day and the calculation of differences between increment and consumption shows that in minimum one village the surrounding forests are overused for firewood collection. Pressure on the forest and the overuse of preferred tree species for firewood can lead to an overuse of the resource and to a decrease in the genetic diversity of these species in the walnut-fruit forests which are considered as a biodiversity hotspot of international significance due to the diversity of woody.

Keywords: swalnut; Juglans regia; firewood consumption; overexploitation

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Introduction

Forests of walnut (*Juglans regia* L.) and other fruit-bearing woody species grow in the southern part of Kyrgyzstan. These walnut-fruit forests (WFF) are considered a biodiversity hotspot (Fisher and Christopher 2007) of international significance due to the diversity of woody (Vavilov 1931; Venglovsky 2006) and avian species (Rehnus et al. 2011).

During Soviet times, the state provided the local people with electricity and charcoal for heating purposes and gas for cooking, but many households continued to use wood, especially for baking bread. However, after Kyrgyzstan gained independence in 1991, the importance of the primary sector for food- and energy-supply increased significantly (Müller and Sorg 2001; Gottschling et al. 2005; Schmidt 2007). Today, firewood is again by far the most important energy source for the population living in the vicinity of the WFF (Schmidt 2007). Due to an increasing demand for firewood from a growing population (Colfer and Schmidt 2005), the amount of readily available dead wood has decreased rapidly (Gottschling et al. 2005). This has led to a discussion about the sustainability of current firewood use inclusive allocation of official permits for firewood collection (Müller and Sorg 2001). In this study, we investigated (1) firewood collection and use practices in three selected villages, including the identification of key influencing variables and (2) analysed differences between the annual increment of woody biomass and firewood consumption for heating during winter months (In this contribution, the term winter stands for the entire heating period from 1 September till 31 May.).

Material and methods

Study area

The study was conducted in three selected villages associated

with the three state forest farms (lezkhoze) Ortok (N 41°12′; E 73°14′; 1507 m a.s.l.), Kaba (N 41°16′; E 72°50′; 1597 m a.s.l.) and Arslanbop (N 41°20′; E 72°55′; 1448 m a.s.l.) in the area of the WFF in southern Kyrgyzstan. The climatic conditions were temperate, with up to 1,090 mm of annual precipitation (Ak-Terek-Kaba forest tract at 1748 m a.s.l.), an average July temperature of 20.5°C and an average January temperature of -3.1°C (Grisa et al. 2008).

Data collection

To identify the woody species on which there is greatest pressure due to firewood collection by local people (e.g. by the perceived heat value), we determined the species composition, measured the total volume (m^3) and the volume per species and visually assessed the degree of dryness (air-dry, semi-dry, green) of firewood collected by four randomly selected farmers. To learn more about firewood collection and estimate of the consumption, we handed out 60 questionnaires to randomly selected informants in Arslanbop, Kaba, and Ortok during June-October in 2009. The response rate was around 87% (52 households). In these surveys, we asked farmers for characteristics of their households to describe their way of collection and use of firewood and alternative fuel, and whether they thought they would continue using firewood for heating in future. This allowed determining how location-related factors influence firewood consumption, such as access to firewood and distance to collection sites, the amount of labour required for collection (Fox 1984), heating needs (e.g. duration of heating period, number of rooms) (Hartter and Boston K 2007), and use of alternative fuel (Bhatt and Sachan 2004; Mead 2005).

Data analysis

The responses from the villages were analysed separately, as the natural environments of the villages differ. To compare the results with other studies, we transformed recorded volumes in stere (volume of stacked firewood including empty spaces) to cubic meter (m^3, volume of wood only) using 0.43 m^3 wood/stere as conversion factor. This factor was derived by measuring firstly the volume of stacked firewood of two randomly selected stacks and two truckloads (trucks: GAS 66, GUL 31) of firewood in stere and secondly the volume of all pieces of wood individually in m^3, summing the latter volumes up to wood-only volumes for the stacks and loads and subsequently calculating the ratio m^3 wood/stere. The weight values are based on the assumption that 1 m^3 of wood weighs 700 kg on average (Foley and Barnard 1984). To identify factors influencing firewood consumption, we used model selection identifying the models best supported by the data (Burnham and Anderson 2002). As potential influencing variables we used the distance between the house and the collection site, the use of alternative fuel for heating, and the number of heating days and heated rooms. Models were ranked according to the second-order Akaike information criterion (AICc) values. Models with AICc values < 2 were considered equivalent to the model with the lowest AICc value (Burnham and Anderson 2002). Furthermore, Akaike weights were calculated to indicate the level of support of a given model relative to all other models in the candidate model set (Burnham and Anderson 2002) for which the sum of the Akaike weights was >95%. Finally, we compared the projected firewood consumption for heating during winter per site with the annual increment of woody biomass (m^3/ha/year). We used an average increment of 0.75 m^3/ha/year, as *Juglans regia* grows at a rate of 1 m^3/ha, *Prunus* ssp. and *Crataegus* ssp. at 0.5 m^3/ha, *Malus* ssp. at 0.75 m^3/ha in the WFF (Venglovsky et al. 2010).

Results and discussion

Total volume of the four different firewood collections used to identify tree species was 18.669 m^3. In these collections, the following species were recorded, ranked in the order of the species preference for firewood given by the four informants (perceived heat value). A separation of tree species by their heat value as perceived by the informants gave the following results: *Malus* ssp. (33.0% of the clubbed volume of the four analysed collections; range: 14.0%–42.0%), *Crataegus* ssp. (21.3%; 14.0%–35.0%), *Acer* ssp. (15.0%; 14.8%–22.2%), *Juglans regia* (3.4%; 0.7%–3.8%), *Prunus* ssp. (0.5%; 0.5%–0.7%), and other species (26.8%; 19.4%–42.5%). This ranking is only partly in line with previously findings (Schmidt 2007), which indicates that the species composition of the firewood collected by farmers in the WFF depends also on the availability of different species. 52.6% of the collected wood volume was green, 29.2% dry, 6.7% semi-dry (11.5% of the volume could not be categorized). The high percentage of green and semi-dry wood indicates an insufficient availability of dry wood in the surrounding forests. Green wood needs time and space to dry to become good fuel.

The heating period typically starts in September and finishes in May (see number of heating days in Table 1). The data indicate a high current and partly future demand for firewood by local people. While all informants used firewood for heating, there are considerably differences between the sites in the use of alternative sources of energy. The calculated individual firewood consumption is on average 3.90 kg/capita/heating day (3.19–6.97 kg/capita/heating day). This is comparable with values reported from other mountain areas (Maikhuri 1991; Bhatt et al. 1994). Firewood consumption is positively related to the number of heated rooms (model-averaged parameter estimate±SE: 0.29±0.05, N = 52). It decreases where alternative sources of energy, such as electricity or coal, are available (-0.23±0.05). Thus, we found that Arslanbop had lowest calculated individual firewood consumption because there the most alternative energy sources are available. Note that the collection of green firewood is forbidden by law and that all forests are state-owned. Similar results have been found in other areas (Mead 2005). Furthermore we assumed that this may be the result of the smaller relative abundance of firewood in general in the forests surrounding Arslanbop where a high population pressure on the forests is than in other two villages (Schmidt 2007).

Table 1. Characteristics of informants (N=52), their households, firewood collection and fuel use in Arslanbop, Kaba and Ortok during the interview survey in year 2009.

Investigation sites	Informants (Number)	Household members (Number)	Heated rooms (Number)	Heating days (Number)	Use of combined heating methods (% of households)	Heating with dung (% of households)	Heating with electricity (% of households)	Heating with coal (% of households)	Heating with wood (% of households)	Collection distance (km)	Use of wood for heating in future (% of households)
Arslanbop	28	6.5±0.6	2.1±0.2	148.6±7.3	71.4	3.6	32.1	53.6	100	17.7±1.3	17.9
Kaba	8	7.3±0.8	2.1±0.4	125.1±10.6	37.5	37.5	0	0	100	7.7±0.7	25
Ortok	16	6.2±0.7	2.4±0.3	161.1±10.3	6.3	0	6.3	0	100	5.3±0.8	75

Arslanbop showed the least availability of forest area per person (Table 2), an indication of the high human pressure on the forest in these regions. Thus, the calculation of differences between annual increment and firewood consumption for heating in winter shows that in Arslanbop, the surrounding forests were overused for firewood collection. The most intense exploitation occurred near the settlements (Schmidt 2005), making it necessary for local people to travel further to cut enough firewood for the winter season (Table 1). The effective total volume of firewood used annually in all the three villages was higher than the projected consumption for winter heating, as firewood is also used for cooking throughout the year (Schmidt 2007) and used illegally (Schmidt 2005). Based on our findings and given the substantial increase in human population and a corresponding decrease in forest area (Müller and Sorg 2001; Gottschling et al. 2005; Colfer and Schmidt 2005; Venglovsky 2006), we expect the people of many villages in the WFF to face an increasing scarcity of fuel wood in the coming few years.

Table 2. Firewood consumption and annual increment for state forests of the three villages.

Investigation sites	Average individual firewood demand per winter ($m^3 \cdot capita^{-1} \cdot winter^{-1}$)	Total number of persons within a distance of 1 km to the state forest*	Forested area per state forest* (ha)	Forested area per person (calculated, ha)	Projected firewood consumption of all persons in the state forest		Annual increment per state forest		Difference annual increment - projected firewood consumption	
					$m^3 \cdot winter^{-1}$	$m^3 \cdot ha^{-1} winter^{-1}$	$m^3 \cdot year^{-1}$	$m^3 \cdot ha^{-1} \cdot year^{-1}$	$m^3 \cdot year^{-1}$	$m^3 \cdot ha^{-1} \cdot year^{-1}$
Arslanbop	0.72±0.11	17,948	12,739	0.71	12,990	1.02	9,554	0.75	-3,436	-0.27
Kaba	1.18±0.17	2,298	4,281	1.86	2,703	0.63	3,211	0.75	508	0.12
Ortok	0.76±0.16	6,371	8,363	1.31	4,839	0.58	6,272	0.75	1,433	0.17

* (Grisa et al. 2008).

Conclusions

Firewood is the main source of energy for local people in the WFF. Pressure on the forest and the overuse of preferred tree species for firewood can lead to an overuse of the resource and a decrease in the genetic diversity of these species. Alternatives sources of energy (e.g. coal, electricity) could help reducing firewood consumption in the region. However, these are often not available or too expensive or lead to a reduction of agricultural productivity (e.g. dung). Improved building practices such as better insulation could in the mid-term also contribute to reductions in firewood needs. However, the task of forest management is to assess which alternatives are viable and to develop the capacities to use these resources. The high demand for firewood necessitates an integrated multifunctional management ensuring resource availability for local people and conserving the economic and ecological services of the WFF (Rehnus et al. 2013). Besides, one should envisage to create new resources for firewood, e.g. to reforest parts of the state forest farms which are today not covered with forest.

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